Appendix A

Alternative Evaluation Study

San Juan Basin Energy Connect Project

Alternative Evaluation Study

January 2012

Prepared for:

Rural Utilities Service
United States Department of Agriculture

Submitted by:

Tri-State Generation and Transmission Association, Inc.

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Abbreviations and Acronyms

°C	Degree Centigrade
AN	Audible Noise
APE	Area of Potential Effect
APLIC	Avian Power Line Interaction Committee
APP	Avian Protection Plan
BGEPA	Bald and Golden Eagle Protection Act
BLM	Bureau of Land Management
CDOW	Colorado Division of Wildlife
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Discharge Permit System
CFR	Code of Federal Regulations
CIG	Colorado Interstate Gas Company
CLRTPG	Colorado Long Range Transmission Planning Group
dBA	A-Weighted Sound Pressure
EA	Environmental Assessment
EMF	Electric and Magnetic Fields
EO	Executive Order
EPM	Environmental Protection Measure
EPTP	Eastern Plains Transmission Project
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HPX	High Plains Express
I	Interstate
IF	Isolated Find
kV	Kilovolt
kV/m	Kilovolts Per Meter
L50	Noise Levels in A-Weighted Decibels
Leq	Equivalent Sound Level
LRR	Land Resource Region
MBTA	Migratory Bird Treaty Act
mG	Milligauss
NAS	National Academy of Sciences

NEPA	National Environmental Policy Act
NESC	National Electric Safety Code
NHPA	National Historic Preservation Act
NIEHS	National Institutes of Environmental Health Sciences
NIH	National Institutes of Health
NLCD	National Land Cover Database
NRC	National Research Council
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
OAHP	Office of Historic Preservation
OPGW	Overhead Optical Groundwire
ROW	Right-of-Way
RUS	Rural Utilities Service
RV	Recreational Vehicle
SDS	Southern Delivery System
SHPO	State Historic Preservation Office
Tri-State	Tri-State Generation and Transmission Association Inc.
USACE	U.S. Army Corps of Engineers
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
V/m	Volts/Meter
VRM	Visual Resource Management
Western	Western Area Western Area Power Administration
WOUS	Water of the United States

1.0 Introduction

Tri-State Generation and Transmission Association, Inc. (Tri-State) is proposing to construct a 230-kilovolt (kV) transmission line that will originate at the Western Area Power Administration (Western) Shiprock 345/230kV substation, located in north-central San Juan County, New Mexico. From Shiprock, the 230kV line would extend to a new 230kV Substation (Kiffen Canyon Substation) (with phase shifting transformers to allow control of power flow) located north of the City of Farmington's (COF) existing Glade Tap Substation. The proposed line would continue northeast to terminate on the La Plata Electric Association (LPEA) 115kV system near Ignacio, Colorado, at a new 230/115kV Substation to be called Iron Horse. The project is called the *San Juan Basin Energy Connect Project* (Project).

1.1 Description of Tri-State Generation and Transmission Association

Tri-State is a wholesale electric power supplier owned by the 44 distribution cooperative members that it serves. Tri-State generates and transports electricity to its member-owners throughout a 250,000 square-mile service territory across Colorado, Nebraska, New Mexico, and Wyoming. Tri-State owns, operates, and maintains an extensive transmission system in these four states consisting of more than 5,200 miles of transmission lines ranging from 115kV to 345kV.

Tri-State, founded in 1952 by 14 original member systems, today serves more than 1.4 million consumers in four states. Tri-State's mission is to provide its member-owners a reliable, cost-based supply of electricity while maintaining a sound financial position through the effective use of human, capital, and physical resources in accordance with cooperative principles.

Tri-State provides wholesale power to its member-owner distribution systems, which in turn provide retail power to farms, homes, and commercial businesses in their respective service areas. LPEA is a member-owner of Tri-State and serves the bulk of the load which is to be served by the proposed Project. To a lesser extent the Project will provide capacity for load growth within the Empire Electric Association (EEA) and San Miguel Power Association (SMPA) service areas as well as provide a potential source for future service to Tri-State member loads in northern New Mexico. Tri-State is obligated by long-term contracts to provide power and energy to serve its member loads.

1.2 Purpose of the Alternative Evaluation

The Project requires right-of-way grants, easements and or permits from the U.S. Department of the Interior's Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), and the New Mexico State Land Office (SLO) and requires interconnection to Shiprock Substation owned by Western. Tri-State is pursuing financial support for the project from the U.S. Department of Agriculture's Rural Utilities Service (RUS). The RUS electric program provides capital loans to electric cooperatives for the installation, upgrade, expansion, and replacement of the electric infrastructure in rural areas. Environmental approvals from BLM, BIA, Western and RUS will require the completion of an environmental review under the

National Environmental Policy Act (NEPA). BLM has been identified as the lead agency for environmental approval of the project, with BIA, Western and RUS identified as cooperating agencies. BLM determined after the initial round of public scoping that an Environmental Impact Statement (EIS) will be prepared for the Project.

This Alternative Evaluation Study (AES) assesses the system and non-system alternatives that best meet the purpose and need for the Project. Tri-State has completed a Macro Corridor Study (MCS) under separate cover in addition to this AES. The information contained in the MCS and AES will be utilized to support the route identification process, right-of-way grant applications, EIS document, local permitting and related public participation processes.

1.3 Purpose for the Project

The primary purpose for the Project is to:

- Relieve transmission constraints and improve power delivery infrastructure in the San Juan Basin Region.
- Serve growing and new loads within the area served by Tri-State member La Plata Electric Association without further constraining the limited capacity regional transmission path known as TOT2A.
- Directly improve the load serving capability and reliability of the electrical system serving LPEA, EEA, and SMPA.

1.4 Need for the Project

The ability to serve additional loads in southwest Colorado is limited by TOT2A, a constrained path recognized by the Western Electricity Coordinating Council (WECC Path 31). The path rating for TOT2A has been determined by technical studies of the interconnected transmission system and is based on a specific set of system conditions, such as generation dispatch and local load. The transfer capability of the path is the amount of power that can reliably be moved across the path. The transfer capability of TOT2A is shared by Western, Tri-State and Public Service Company of Colorado. As stated above, the primary purpose of the Project is to serve additional load in the LPEA service territory. The challenge is to serve that additional load without compromising the transfer capability of TOT2A and negatively affecting the transfer rights of the path owners.

In addition to the TOT2A constraint, the existing 115kV system serving the LPEA service area is also limited. Most of the LPEA load is served from the Hesperus-Durango-Bayfield-Florida River 115kV transmission loop; although the Durango area is served by a second 115kV line between Hesperus-Bodo-Durango. The north side of the Hesperus-Durango-Bayfield-Florida River 115kV system is owned by Tri-State. The southern side of the transmission system, from Hesperus through Florida River to Bayfield is owned by LPEA. From Bayfield, Tri-State owns a radial 115kV line that terminates at Pagosa Substation. Most of the forecasted load growth driving the need for the proposed Project will be concentrated

east of Hesperus near Bayfield and Ignacio, Colorado. The existing 115kV system is insufficient to accommodate that forecasted load.

As noted above, two of LPEA's primary 115kV transmission lines are sourced from the same location, Hesperus Substation. For practical purposes, the lines are "radial" and of limited capacity. Should a problem occur at Hesperus, both lines would be adversely affected. This common source does not permit power to be rerouted when a line section must be taken out of service for repair or when a problem occurs during peak load periods. As a result, these lines are not capable of providing the same level of system reliability that could be achieved with an additional transmission source into the area. A new line from an alternate transmission source would provide redundant service (as compared to a radial fed source) and improve the dependability and reliability of electrical service to LPEA's customers.

The need for additional transmission capacity in the area is documented in the *Large Load Serving Study Report for La Plata Electric Association, Inc., San Juan Major Project*, dated January 2008. Additional alternatives were studied in the *Alternatives Addendum* to that Study, dated December 2008. These studies document that the existing lines in the LPEA service area do not possess sufficient capacity to power the forecasted loads.

LPEA has forecasted increasing residential, commercial and industrial needs for electricity within its service territory and has requested that Tri-State ensure that the transmission system is adequate for serving these load additions. A major factor contributing to the increase in forecasted load is the agreement between La Plata County and gas producers to utilize electricity when adding new wells to local infill areas (http://www.co.laplata.co.us/departments_elected_officials/planning/natural_resources_oil_gas/mou). A LPEA updated industrial load forecast of 100 MW was used for purposes of this AES and was provided by LPEA. That load was combined with Tri-State's 2009 forecast for its other southwest Colorado area loads and was revisited to compare it with Tri-State's 2011 sales forecast. In doing so, the need for the proposed Project was confirmed. The total southwest Colorado load encompasses the majority of the electrical loads served in Delta, Dolores, La Plata, Montezuma, Montrose, Ouray, San Juan and San Miguel counties. The actual 2010 winter peak loads for the Tri-State members in southwest Colorado are tabulated in Table 1.

Table 1: Southwest Colorado Historical Loads

Tri-State Member System	Winter 2010–11 (December) Coincident Peak Load(megawatts)
LPEA	166.1
EEA	88.1
SMPA	48.5
Total Tri-State southwest Colorado member load	302.7

Source: Tri-State History Sales Report

2.0 Project Description—Proposed Action

The proposed Project involves the construction of a 230kV transmission line connecting the existing Western-owned Shiprock Substation in San Juan County, New Mexico, to the new 230/115kV Iron Horse Substation located in La Plata County, Colorado near Ignacio. Associated construction will include the Kiffen Canyon Substation, with phase-shifting transformers, near the COF's Glade Tap Substation. The distance between the Shiprock Substation and proposed Iron Horse substation is approximately 70 miles. The actual length of the transmission line will be determined with final route selection. The transmission line between the Shiprock and Kiffen Canyon Substations will use double-circuit capable transmission structures. The transmission line between Kiffen Canyon and Iron Horse Substations will use a combination of double-circuit capable and single-circuit structures. The Project study area encompasses approximately 2,100 square miles and is shown on Figure 1.

2.1 Right-of-Way Considerations

The new transmission line is proposed to be constructed within a right-of-way (ROW) approximately 150 to 200 feet in width, depending upon final engineering design. Tri-State representatives will work with the landowners along the selected route to obtain the necessary land rights to allow for access, construction, operation, and maintenance of the new transmission line.

2.2 Proposed Structures

The typical physical design characteristics for the transmission structures proposed to be used for the transmission line are listed in Table 2. Diagrams showing the proposed transmission structures are presented in Figure 2.

Table 2:
Typical Proposed Transmission Line Characteristics

Design Component	Double Circuit		Single Circuit
	Steel Lattice Structures	Steel Mono-Pole Structures	Wood H-Frame Structures
Voltage	230kV		
Typical Right-of-Way width (feet)	150		
Average Span (feet)	800–1200	800–1200	800–1100
Typical range of structure heights (feet)	100–150	100–150	65–100
Number of structures (per mile)	4–6	4–6	4–7
Minimum ground clearance beneath conductor (feet)	28	28	28
Maximum height of machinery that can be safely operated under the line (feet)	14	14	14

Figure 1: Project Study Area Map

Double-circuit construction will be accomplished using steel lattice or steel monopole structures. Single-circuit construction will be accomplished using two-pole wood H-frame structures. The structures vary in height, depending on the distance between the structures and the area topography. Taller structures may be used for crossing streams, roads, other transmission lines or where unusual terrain exists. The distance between structures typically ranges from 800 to 1,200 feet depending upon topography.

The steel lattice and steel monopoles (figure 2a) will be designed to accommodate three conductors in a vertical array on each side of the pole. The H-frame (figure 2b) structures will be designed to support three conductors horizontally on individual insulators located below the top of the pole(s). At the top of the each type of structure, two overhead ground wires ("shield wires") will be utilized to protect the transmission line from lightning strikes. One of the shield wires may contain fiber optics for communication needs.

Depending upon local conditions, other types of structures may be required as well. For example, three-pole wood-angle structures with guy cables will typically be used where the single-circuit transmission line changes direction. Along sections of the line where wood H-frame structures are used, three-pole wood dead-end structures with guy cables in both directions will be installed every 5 miles to prevent cascading type structure failures caused by storm damage.

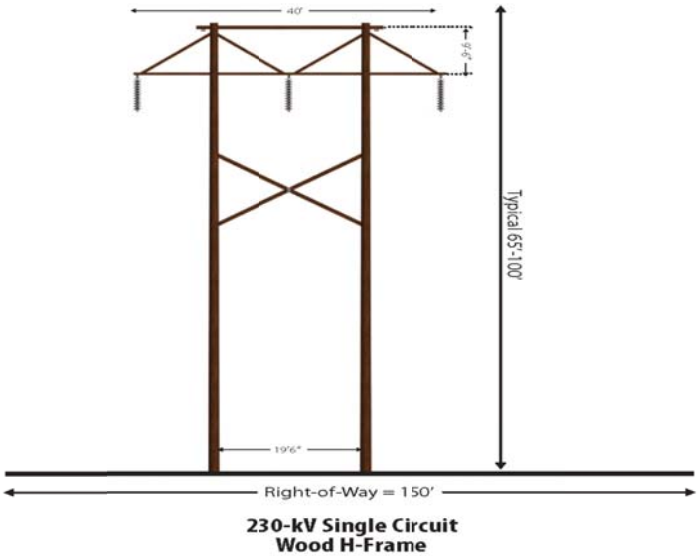

Figure 2b: Proposed 230kV Transmission Structures

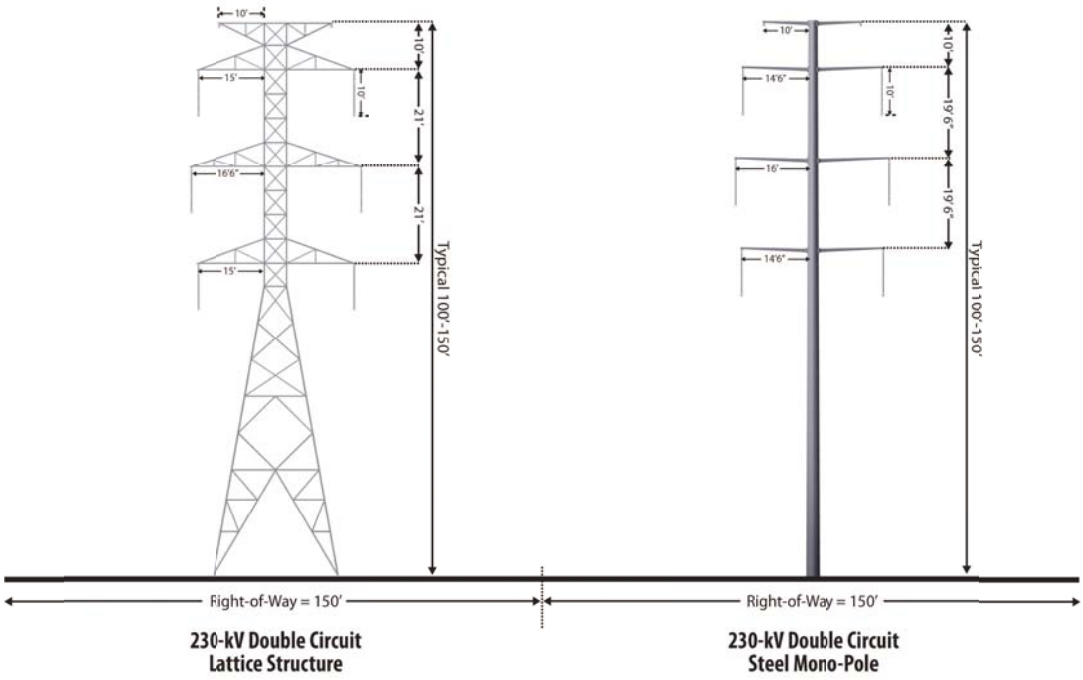

Figure 2a: Proposed 230kV Transmission Structures

3.0 Alternatives Study - Alternatives Considered

In the sections below, the "no action" alternative, and the alternatives that address each aspect of the Project's purpose and need are discussed. As stated previously in this report, the critical need is to provide improved electrical system capacity to serve increasing residential, commercial and industrial load growth within the LPEA service territory without further constraining TOT2A. Various alternatives were investigated to meet these needs.

3.1 No Action Alternative

The "no action" alternative cannot serve the projected load increase. As noted in the *Large Load Serving Study Report for La Plata Electric Association, Inc., San Juan Major Project*, dated January 2008, the existing 115kV transmission system has insufficient capacity and is therefore unable to accommodate the expected load additions. Certain network upgrades, such as line uprates and the addition of capacitor banks may provide temporary voltage support to the 115kV system and accommodate some load increase. However with the addition of significant load in the Ignacio area, it will no longer be possible to maintain acceptable system voltages. Voltage levels could potentially collapse, resulting in major system outages. Allowing system voltages to collapse without action does not meet NERC/WECC Reliability Standards or Tri-State's obligations as a transmission provider to its member-owners and other transmission providers.

Adding significant load under the no action alternative will also result in reducing the transfer capability between Colorado and New Mexico for Tri-State and the other transmission owners of TOT2A.

3.2 Additional Generation Capacity

Adding generation to serve the forecasted load instead of constructing the propose Project was considered. However, a significant driving force behind the industrial load growth in the San Juan Basin is the La Plata County requirement that minor gas facilities with engines or motors be electrified to minimize sound and air emissions (La Plata County Oil and Gas Provisions, Chapter 90). Installation of additional generation as an alternative to the construction of the proposed Project may face similar air quality issues as those gas powered engines and motors, depending on the type of generation selected.

The electrical load factor in the LPEA service area is very high because the existing electrically driven compressors in the area are in use about 95 percent of the time. Certain renewable generation resources, such as wind and solar, could be considered in order to avoid the air quality concerns cited above. However, these particular energy resources are intermittent in nature and are not always available for operation. Therefore, for this particular application, they are not considered viable alternatives because of the high-load factor service requirements of the forecasted loads. The installation of intermittent generation resources also does not solve the reliability issues described in Section 1.3 of this report.

Utilities often consider conventional gas-fired Simple Cycle Combustion Turbines (SCCT) as the most economical generation to serve these types of load additions. Advantages to SCCT projects are their low capital cost, short design and installation schedules, and wide availability. However, the installation of SCCT generation as an alternative to the construction of the proposed Project may face the same air quality issues that are driving the conversion of existing natural-gas-powered compressors to electricity, and the associated permitting problems. Furthermore, if the air quality issues require that the SCCT generation be physically located remote from the loads, then the electrical system, by necessity, would require the construction of new transmission lines from that generation to the load area. In that event, the generation resource would not replace the need for transmission line construction, but would require additional transmission itself.

The load factor in the LPEA service area noted above complicates the selection of generation. Instead of two or possibly three smaller generation units supplying the load, at least one additional unit would have to be installed to allow for outages and routine maintenance of the units (N-1 contingencies). Reliability concerns with the generation units themselves could also require additional backup unit capacity.

Another consideration with the sizing and number of combustion turbines (CT) is the “derating” of the turbines due to the altitude of the San Juan Basin. The performance of a CT is highly dependent on air density and/or mass flow of the air intake to the compressor. Anything that affects the gas turbines ability to “breathe” in-turn affects performance. The

altitude of the San Juan Basin is approximately 6500 feet above mean sea level (amsl), requiring the application of a 0.65 correction or derating factor per GE reference manuals. Because of such correction factors, installations above 4,000 feet amsl become decreasingly cost-effective. The result is that larger and more expensive CT units are required to provide the equivalent output power.

With the above considerations, Tri-State investigated the installation of CT generation to serve the forecasted LPEA load. Three configurations and three different CT units were evaluated. The intent of each configuration was to provide between 200 and 300 MW of generation resource with enough CT capacity to allow for any N-1 contingency. The analysis assumed that fuel will be available at the plant site boundary. No detailed analysis was done regarding natural gas availability or concerning gas line interconnection and distribution costs.

Considering capital costs only, it is clear that adding generation in La Plata County is not a cost effective alternative to any of the transmission options. The *lowest* capital cost generation alternative substantially exceeds the *highest* capital cost transmission option. That cost differential increases when integrating fuel costs and CT operation and maintenance costs.

3.3 Demand Side Management

Programs have been implemented throughout Tri-State's member systems to promote energy conservation. These programs been in place for more than 20 years and have been successful in helping to minimize the energy used and limit the maximum coincident peak load.

Since 1985, Tri-State (through its member cooperatives) has been offering financial assistance toward the purchase of high-efficiency motors and pumps to reduce electrical demand. The cooperatives have had a program called Energy Efficiency Credits (EEC) in place which provides cash rebates to encourage and reward wise use of energy through energy-efficient purchases and practices. Through the EEC program, Tri-State and the Tri-State member cooperatives have already reduced demand by over 75 MW (over the entire system) and saved more than 80,000 megawatt hours (MWh) of energy. Tri-State and the Members have expanded the EEC program to make it Energy Star based. Additional measures and programs have been offered since early 2009 and have been expanded since that time.

The individual Tri-State member systems also have energy efficiency and demand-side management (EE/DSM) programs which their systems offer. All three of the members serving member-consumers in the San Juan Basin offer consumers appliance use information, energy use information, conservation guides, web-based conservation strategies and links, web-based energy calculators, free energy audits and conservation programs, Compact Fluorescent (CFL) programs, and time-of-use rates. Each also has line loss reduction strategies in place and participates through Tri-State in Electric Power Research Institute

(EPRI) and Cooperative Research Network (CRN) research into EE/DSM programs, measures and products.

Tri-State staff has conducted and participated in planning sessions with its members to expand their programs and include additional demand response. For certain loads, this sometimes requires installation of expensive communications and metering equipment, and upgrading distribution infrastructure. These investments are underway. Tri-State is working with its members to support smart grid expansion which will support additional demand response.

Pertaining to EE/DSM, Tri-State performed a comprehensive end-use energy efficiency/demand side management/demand response study across its entire system. This study examined the technical, economic, practical and actual energy and demand reduction potential. The study measured potential in discrete geographic regions, such as the San Juan Basin, and identified those programs and measures that will have the most value to the member-consumers of Tri-State.

An alternative to centralized generation and distribution of electrical energy is the installation of distributed generation. Distributed generation is built on the concept of installing generation at or near the point of use. Solar, wind, or other alternative types of generation could be installed by the end-user to meet specific needs. Residential loads, for example, can be reduced with the application of small solar or wind energy systems. This would tend to reduce existing loads in the San Juan Basin and/or permit the installation of new load. It may also reduce the risk of electrical service interruption or more severe vulnerabilities such as voltage collapse for an N-1 contingency.

Certain demands, such as irrigation, represent a scheduled load and are not good candidates for solar- or wind-generated power. However, this need could possibly be met with some type of generator located near one or more of the irrigation pumps. Typically, this would need to be powered by gasoline or diesel engines to be available when irrigation was required. The owners and operators of irrigation systems currently have the option of installing local generation; however, the electric cooperative’s obligation is to serve the member loads with the best alternative based on economic and environmental choices.

Tri-State has adopted several Board Policies that enable and provide incentives to member systems and their member consumers to participate in and install local renewable projects that can count for renewable portfolio standard compliance in Colorado. These policies and the policies of the member boards provide for net metering at the member-consumer premises for small community-based projects. Each of the members offers net-metering programs and continues to evaluate local renewable projects. Each also participates through Tri-State in EPRI and CRN research into distributed generation and distributed energy systems. Notwithstanding the attraction of such small projects, they do not accomplish what is necessary to meet the purpose and need for the proposed Project.

In summary, programs have already been implemented that are designed to be compatible with the primary loads experienced on the member systems. These programs are effective in promoting energy conservation and local renewable energy development. They have been in place for a number of years, and have been successful in helping to minimize the energy used in the San Juan Basin and to minimize the load at the time of system peak demand. Tri-State will continue to promote these programs in the future. However, it is recognized that it takes years to build out EE/DSM and distributed generation/local renewable projects that will have a material impact on local load and energy requirements.

As industrial and residential load growth in the San Juan Basin continues, it is unrealistic to expect that the total system peak load in the San Juan Basin can be sufficiently reduced to effectively meet the load forecasts and to solve existing transmission deficiencies. Even aggressive EE/DSM techniques are not effective in eliminating or controlling the high load factor and reliability issues associated with or caused by the increase in industrial load.

3.4 Additional Transmission Capacity

Tri-State studies were initiated with power-flow models based upon requests from LPEA for additional capacity as indicated in this report. System models were prepared using existing loads as well as LPEA and Tri-State load projections to provide a test of the ultimate system requirements to serve the projected load. Single contingency power flow analysis was performed using a 2016 summer case (WECC16HS1A) for each transmission alternative. The summer base case was modified to extrapolate the 2016 loads in areas surrounding LPEA to a level for the base year of 2021. Except for the facilities necessary to serve the LPEA load for each alternative, no new generation or transmission lines were added to the 2021 case above that included in the 2016 WECC base case.

The following standard planning criteria was used to evaluate the system performance of the alternatives studied:

Voltage:	Between 95% and 105% of nominal voltage
Voltage deviation:	5% maximum change with any single outage
Power flow:	80% of maximum rating under normal conditions
Outage power flow:	Not to exceed 100% of maximum rating

The main source of power for the LPEA service territory is an existing 115kV transmission system, the source of which is the 345/115kV Hesperus Substation located near Durango, Colorado. Additional existing sources are the 115kV transmission line from Lost Canyon Substation located near Cortez, Colorado and the 115kV transmission line extending to Western's Shiprock Substation in New Mexico through the COF transmission system. Most of the LPEA load is presently served from the existing Hesperus-Durango-Bayfield-Florida River 115kV transmission loop.

As the industrial load increases prior to construction of a new transmission line into the Bayfield area, Tri-State may have to rebuild its existing Hesperus-Durango 115kV line.

Additionally, reactive support will be required to maintain acceptable voltage profiles on the Hesperus-Durango-Bayfield-Florida River 115kV loop. Approximately 22.5 megavolt ampere reactive (MVAR) of additional capacitors will be needed initially. An additional 37.5MVAR bank of capacitors will be needed at the new Iron Horse substation as the loads increase. These changes are included in the power flows that constitute the system model used in the planning studies.

The results of the planning studies indicate that to increase the load serving capability and avoid degrading the transfer capability of TOT2A, an additional transmission line needs to be constructed into the Bayfield load area. Various transmission configurations were studied to serve this increase in the southwest Colorado load requirements. While there could be 345kV variations of these configurations, 345kV lines generally cost about 60% more than 230kV lines. A 230kV source was determined to be sufficient and less costly will provide reliable electric service to LPEA and the expected industrial load growth. Thus, a new 230kV transmission line was identified as the preferred electrical system alternative. The following four transmission system alternative configurations were studied:

- Shiprock–Glade Tap–Iron Horse 230kV line
- Ojo East–Turley–Chama–Iron Horse 230kV line
- San Luis Valley- Chama- Iron Horse 230kV line
- Curecanti–Montrose–Nucla–Florida River 230kV line

3.5 Transmission Alternative Summary

3.5.1 Shiprock–Kiffen Canyon–Iron Horse 230kV Line

This alternative consists of a radial 230kV line originating at Western's Shiprock Substation and extending to the proposed Kiffen Canyon Substation located near the COF Glade Tap 115kV Substation. Phase shifting transformers are used to control power flow on the 230kV line that will be extended to the proposed Iron Horse 230/115kV Substation near Ignacio, Colorado. The Iron Horse Substation will serve the LPEA load in the Bayfield area and the existing 115kV system of the COF at the existing Glade Tap Substation.

The power flow model study indicates that the Shiprock–Kiffen Canyon–Iron Horse proposal meets the electrical needs of the study area as stated in Section 1.3 of this report. The line was determined to be a reliable and cost-effective solution to the load serving needs of LPEA while preserving the transmission transfer needs of the study area. The Shiprock–Kiffen Canyon–Iron Horse 230kV alternative was found to adequately and reliably meet these system needs at the least cost and therefore is the preferred transmission system alternative.

3.5.2 Ojo East–Turley–Iron Horse 230kV Line

This system alternative consists of tapping the Public Service Company of New Mexico (PNM) 345kV line near Gavilan, New Mexico and constructing a 345/230kV Substation at that location. A 230kV transmission line would then be built north to a new substation near the intersection of Pounds Mill Road and Highway 64. At Pounds Mill Substation, a 115kV

transmission line was assumed to serve the Dulce-Chama areas and the 230kV line continued west to the vicinity of Turley, New Mexico and then north toward Ignacio, Colorado (and the new Iron Horse Substation). Phase-shifting transformers and series compensation for the 230kV line are necessary at Turley Substation to provide a controlled input of 250 MW into the LPEA service area. A 125MVAR capacitor bank would be installed at Turley Substation to reduce the impedance seen by the phase-shifting transformers because of the long line length.

The Ojo East–Turley–Iron Horse 230kV alternative was determined to be both slightly more costly with slightly less power transfer capability than the preferred transmission system alternative. It would also increase loading on the northern New Mexico restricted path.

The Ojo East alternative also appeared to be a less desirable solution based upon discussions with PNM planning personnel since it would require a new tap on PNM's northern New Mexico 345kV transmission system, which is already limited in its available transmission capacity.

3.5.3 San Luis Valley–Chama–Iron Horse 230kV Line

This alternative consists of a radial 230kV line originating at the San Luis Valley Substation north of Alamosa, Colorado. The line would extend south from that location to the Colorado border and then proceed west to a new substation located near Chama, New Mexico. At a new Chama Substation, phase shifting transformers and a 75 MVA 230/69kV transformer was modeled to serve the Dulce-Chama areas. The 230kV line would continue in a westerly direction to the vicinity of Trujillo, Colorado where a 150 MVA, 230/115kV transformer would be the source for a new 115kV line connecting to Tri-State's Pagosa Substation. A 175MVAR capacitor bank would be installed at Trujillo Substation. Tri-State's existing Pagosa-Bayfield 115kV line would be reconductored to accommodate power flow from the Trujillo transformer. The 230kV line would continue west to terminate in the new Iron Horse Substation.

It was determined that the San Luis Valley–Chama–Iron Horse alternative would provide about the same amount of power transfer capability as the preferred transmission system alternative, but at more cost because of the longer line distances.

3.5.4 Rifle–Curecanti–Montrose–Nucla–Florida River 230kV

This alternative consists of a radial 230kV line extending westerly from the Curecanti Substation located east of Montrose, Colorado, past Tri-State's South Canal, Nucla, Cahone, and Empire Substations to terminate at a new 230/115kV Substation near LPEA's Florida River Substation west of Ignacio, Colorado. The 230kV line would be constructed in an existing 115kV transmission line corridor on new transmission structures. The existing 115kV substations would be converted to 230kV. South of the Empire Substation, the 230kV line would be double-circuited to maintain the 115kV source serving the Lost Canyon, Durango, Hesperus, and Florida River substations. In addition, a 225MVAR capacitor bank would be

installed at Empire Substation to reduce line impedances so that power may flow into the LPEA service area.

It was determined that the Rifle to Florida River 230kV alternative would offer significantly less power transfer capability than other transmission alternatives and at a much higher cost than the preferred transmission system alternative.

3.5.5 Transmission System Alternatives Discussion

The first three alternatives ranked below generally meet the needs of the transmission and distribution providers in the study area. The power flow analysis, as documented in the referenced studies, identified the transmission system upgrades and facility additions required for each alternative to accommodate the forecasted load. Those facility additions are required to mitigate certain N-1 conditions and to meet all system design and reliability criteria.

Each of the alternatives investigated was ranked based upon their cost in capital dollars per megawatt of load serving capability. The ranking results for all of the alternatives are documented and tabulated below in Table 3.

Table 3:
Ranking of Transmission System Alternatives by Cost (2011 $)

Rank	High Voltage Transmission Project Alternative for Connection to LPEA near Ignacio, Colorado	System Intact Serving Capability (MW)	Total Project Cost Including future New Mexico Service ($1000)	Initial Project Cost Required for LPEA/Southwest Colorado ($1000)	Projected Route Miles of 230kV Line Required for LPEA/Southwest Colorado	Initial Project Cost per MW of Delivery Capability ($1000)
1	Shiprock–Kiffen Canyon–Iron Horse 230kV	250	$180,885	$132,426	68	$530
2	Ojo East–Turley–Iron Horse 230kV	250	$195,650	$171,835	110	$687
3	San Luis Valley–Chama–Iron Horse/Pagosa 230kV	250	$214,789	$190,481	172	$762
4	Rifle–Curecanti–Montrose–Nucla–Florida River 230kV	100	$256,412	$207,920	201	$2,079

3.6 Preferred Transmission System Alternative

As can be seen in Table 3, the Shiprock–Kiffen Canyon–Iron Horse proposal is the most cost effective solution to meeting the LPEA load serving needs. The line length of the Shiprock–Glade Tap–Iron Horse alternative is significantly less than the other alternatives and therefore has a significantly less overall project cost. The power-flow analysis demonstrated that it

meets the reliability and capacity needs of the San Juan Basin area, including the projected load growth requirements of Tri-State's other affected member systems.

In addition to LPEA, Tri-State members Empire Electric Association, Inc. (EEA) and San Miguel Electric Association (SMPA) have load in southwestern Colorado. Together these cooperatives form the load area which impacts the TOT2A transmission path.

The proposed Project removes approximately 200 MW of new and existing LPEA load from the southwest Colorado load area and prevents further degradation of the transfer capability of the TOT2A path. Approximately half of this capability (100 MW) will source the expected new load growth in the LPEA service territory. The remaining capability is available for the other cooperatives (as well as LPEA) that comprise the southwestern Colorado load area.

Pending arrangements with the COF, a second redundant phase shifting transformer could be used to control power flow into the underlying 115 kV system of the COF at the existing Glade Tap Substation. Part of the TOT2A path is a 115 KV line between Tri-State's Hesperus Substation and the COF Glade Tap Substation. Presently, this 115 kV transmission line is operated normally open when significant power schedules are being transmitted on TOT2A. With a second phase shifting transformer, the flow of power through the COF system could be controlled without opening this line. This would provide a more secure source of power into the area north of Farmington for loads served by the COF, such as Tri-State member Jemez Mountains Electric Cooperative (JMEC).

The second 230 kV line on the double circuit structures from Shiprock would initially be used to reinforce the existing 115 kV system south of the Hesperus 345 kV Substation. Eventually, however, this second 230 kV line could be extended north to upgrade the TOT2A path. Such a project would provide additional transmission capacity and operating flexibility to the San Juan Basin.

3.7 Impact of Preferred Alternative on TOT2A

The TOT 2A transmission path from Colorado into northern New Mexico is defined as the metered flow at the southern end of the following transmission lines:

- Hesperus-San Juan 345kV line
- Durango (Hesperus)-Glade Tap 115kV line
- Lost Canyon-Shiprock 230kV line

Phase-shifting transformers are in place at Waterflow (345kV), near the San Juan Generating Station, and at Shiprock (230kV) to regulate the flow of power across TOT2A. The transfer capability of the path in the north-to-south direction is approximately 690 MW less the net generation and load in southwestern Colorado. Therefore, load additions by LPEA or other Tri-State members in southwest Colorado can have a significant impact on the transfer capability of TOT2A. Past operating studies have confirmed that as southwest Colorado loads increase, there is a decrease in the north-to-south transfer capability of TOT2A.

At a total southwestern Colorado load of approximately 300 MW, the Tri-State share of the transfer capability across TOT2A is exhausted and the other owners' share of transfer capability becomes affected. As the TOT2A transfer capability diminishes, it becomes more and more difficult for other parties to contract for power schedules from Colorado into New Mexico.

The existing southwest Colorado peak hour load on TOT2A is approximately 310 MW. The proposed addition of 100 MW of new industrial load by LPEA will significantly affect the transfer capability of TOT2A during the peak load period. The potential impact is shown in Figure 3, which compares the projected hourly loads to the actual hourly loads in southwestern Colorado. Figure 3 shows that the projected hourly loads for TOT2A will be greater than the actual (historical) recorded peak loads for most of the year.

As was previously stated, the purpose of the proposed Project is to serve significant load increases in the LPEA service territory while preserving, as much as possible, the existing TOT2A transfer capability during peak southwest Colorado load periods. The intent of the Project is not to facilitate additional TOT2A transfer capability above that amount historically achieved, but to preserve the existing transfer capability and provide reliable service to new and existing loads in southwest Colorado. Accordingly, and as proposed, the Project's transmission line does not cross the TOT2A boundary. Instead, it is designed to inject power from existing sources in the Four Corners area into the southwestern Colorado load area. This is to be accomplished by the use of phase-shifting transformers as a part of the Project. Injected power into southwest Colorado will offset the proposed load additions and assist in preserving TOT2A transfer capability.

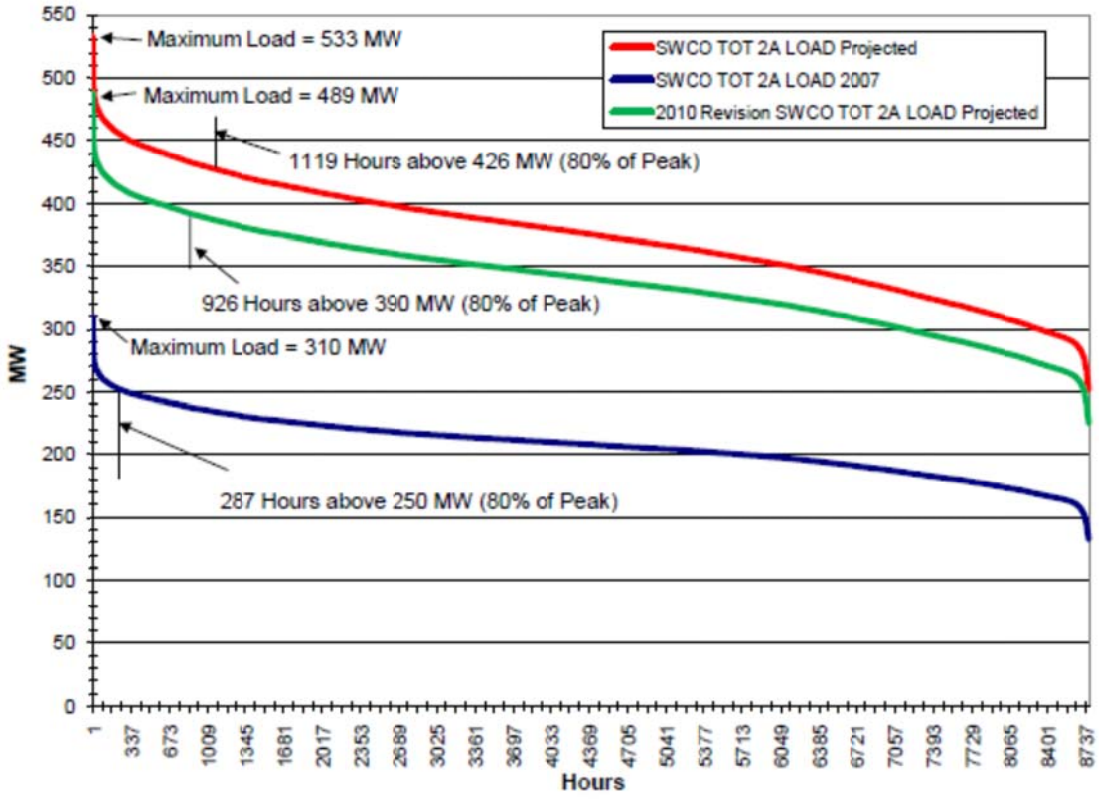

Figure 3: Southwestern Colorado Load Duration Curve on TOT2A

The Western Area Power Administration performed a study titled, San Juan Basin Major Project, TOT 2A Impact Analysis, dated April 6, 2011, to assess the impact of additional load in western Colorado on the transfer capability of TOT 2A. The study specifically addressed the load additions proposed by LPEA. The study found that as loads increase in southwest Colorado, the proposed Shiprock-Kiffen Canyon-Iron Horse project significantly preserves the transfer capability of TOT2A. The TOT2A transfer capability was greater by at least 200 MW for peak load conditions due to the ability of the Shiprock-Glade Tap-Iron Horse 230-kV line and its associated phase shifter to minimize power flow through the Hesperus 345/115-kV transformers.

4.0 Conclusion

Tri-State and Tri-State's member systems have identified the need to serve approximately 100 MW of additional load in the San Juan Basin area. Existing transmission constraints have been identified that preclude service to these loads without additional transmission system infrastructure. Therefore, in order to provide the necessary electrical system capacity and reliability, the Shiprock–Glade Tap–Iron Horse 230kV Project is proposed. Transmission system studies have shown that this Project: (1) accommodates the anticipated load additions, (2) avoids reducing the transfer capability of TOT2A, and (3) directly improves the

load serving capacity and reliability of the existing electrical system serving Tri-State's member systems LPEA, EEA and SMPA.

As discussed in this report, the "no Action" alternative is not acceptable since the existing system does not have the capability to handle the projected industrial loads. Demand-side management programs cannot adequately control the high load factor requirements of these loads. Additional generation would solve the capacity and loading problems, but will not mitigate the issue of local air quality. Moving the generation "off site" would mitigate the local air quality issue, but would also require additional transmission to be constructed into the load area. Therefore the most viable and economic solution to mitigate these issues is the construction of additional transmission facilities into the area. The proposed Shiprock–Glade Tap–Iron Horse 230kV Project is the best of the transmission system alternatives.